Integrated Cave Entrance Community and Cave Environment Long-Term Monitoring Protocol

Appendix B:
Power Analysis for Annual Trends in Townsend's Big-eared Bat *(Corynorhinus townsendi)* Hibernacula Counts

Version 1.0

Revision History Log

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

This document investigates the power for detecting annual trends in hibernacula counts of the Townsend's Big-eared bat.

Power Analysis for Annual Trends in Townsend's Big-eared bat *(Corynorhinus townsendi)* Hibernacula Counts

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Introduction

This document investigates the power for detecting annual trends in Hibernacula counts of the Townsend's Big-eared bat. The proposed sampling design as described by Shawn Thomas of Lava Beds National Monument is described next. Six caves were selected because they are known to contain ~85% of the known population of Townsend's big-eared bats (Caves 1,4, 12, 17, 25, 44). Also, 3 additional randomly selected caves (27, 31, 40) will be monitored every year for bats. LABE will also monitor cave #13, and if time allows caves #30 and #56. This power analysis assumes that all of the cave data will be used for a trend analysis report on the bats in LABE. The bats will be counted each year at these caves and this analysis assumes that there is perfect detectability of bats during the counting process. Based on the targeted selection of these caves, inferring to the entire bat population across all caves in LABE is not statistically justified. Annual trends in bat counts represent only these 10-12 sampled caves, we cannot assume the same patterns hold in the unsampled caves. Given that the majority of the bats are thought to be present in these caves, this is a reasonable choice for sampling bats in LABE due to budget and time constraints.

Initially the plan was to survey bats at 6 caves, therefore in this report we also investigate these sample sizes to determine if that is a sufficient number of detecting annual trends in bat counts over time with the proposed sampling effort of the network.

Power Analysis for Annual Trends in Hibernacula Counts

Power is a function of the variability in bat counts (among caves and years), type 1 error, specified magnitude of annual trend, number of years of sampling, and number of caves sampled. In this analysis we use estimated variance components from pilot data (Figure 1 and 2), set the Type 1 error and magnitude of annual trend, and then investigate power as a function of years and caves. The power analysis is evaluating the probability of rejecting the hypothesis of no trend when in fact there is a specified annual trend (2%, 3%, or 5%). I use a type 1 error, the probability of detecting a trend when in fact there is no trend, of 10%; common for long-term monitoring objectives.

Pilot Data used for estimating variance components

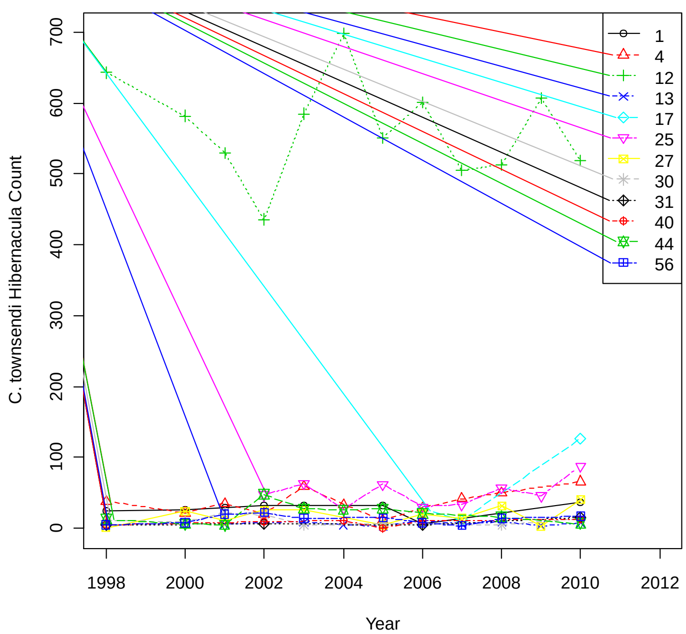

Figure 1. Hibernacula Counts

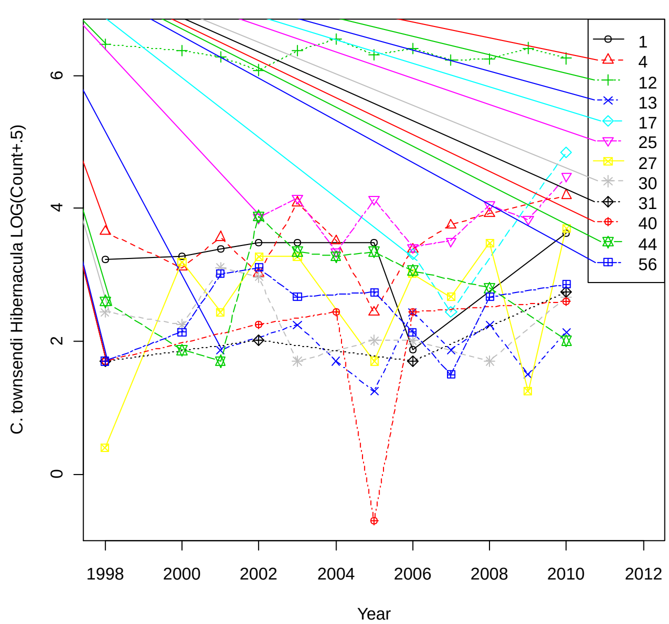

Figure 2. Log transformed Hibernacula counts

Model for Trend Analysis

In order to perform a power analysis for univariate trend, a similar model as that for the climate data is assumed for the future data analysis. I adopt the linear model presented in Urquhart and Kincaid (1999); Larsen et. al (2001); Kincaid et. al (2004); and Urquhart et. al (1993). The model is as follows where is the observed hibernacula count for cave *i* in year *j*, , , ,and the components are assumed independent. The counts are log-transformed because of the large counts in cave 12. A small value is added to the counts to adjust for the one zero count in 2005 at cave 40.

There have been many modifications to this general model idea that allow for varying trends for each site (Piepho and Ogutu, 2002, Van-Leeuwen et al. 1996). However, for computational simplicity I used a model assuming trends over time do not vary by site. I used the functions written by Tom Kincaid to estimate power based on the model above, for specific details refer to the paper by Urquhart et al 1993. These are *estimates* of the power because we are estimating the variance components. Fortunately the available pilot data, although unbalanced (not every cave was sampled every year), is from those caves that are going to be sampled by either the park or the network as part of the caves long-term monitoring protocol. Therefore, the estimated variance components should be representative of both the cave-to-cave variability in counts and the temporal variation across years for the 10 or 12 caves to be sampled for Townsend's big-eared bats.

Results

I used the lmer function in the lme4 package in the *R* freeware statistical platform to estimate the random components of the mixed model using restricted maximum likelihood (REML). The estimated variance components are displayed in Table 1 for log-transformed Hibernacula counts. I looked at all of the caves that may be sampled if time allows and also the subset of 10 caves that will definitely be sampled each year.

Data Used	**Parameter**	**Estimate**
All Caves		1.523
		0.052
		0.383
Only 10 sampled by park+network		1.748
		0.059
		0.411
6 caves sampled		1.559

by network		
		0.007
		0.289

Table 1. Estimated Variance Components using REML for various groups of proposed caves to be sampled.

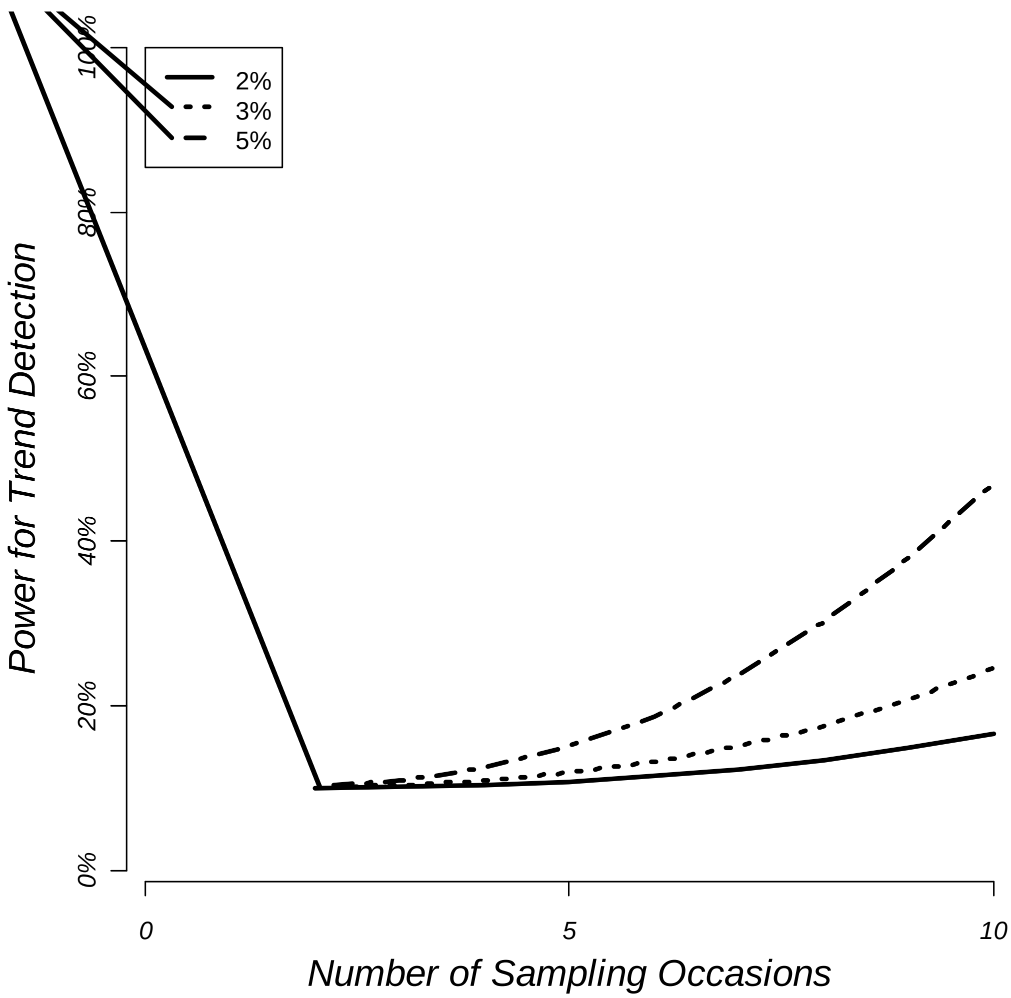

Figure 3. Estimated power for detecting annual trends in the median log-counts of 2%, 3% and 5% for 10 years with 12 caves sampled each year using the variance components of all caves.

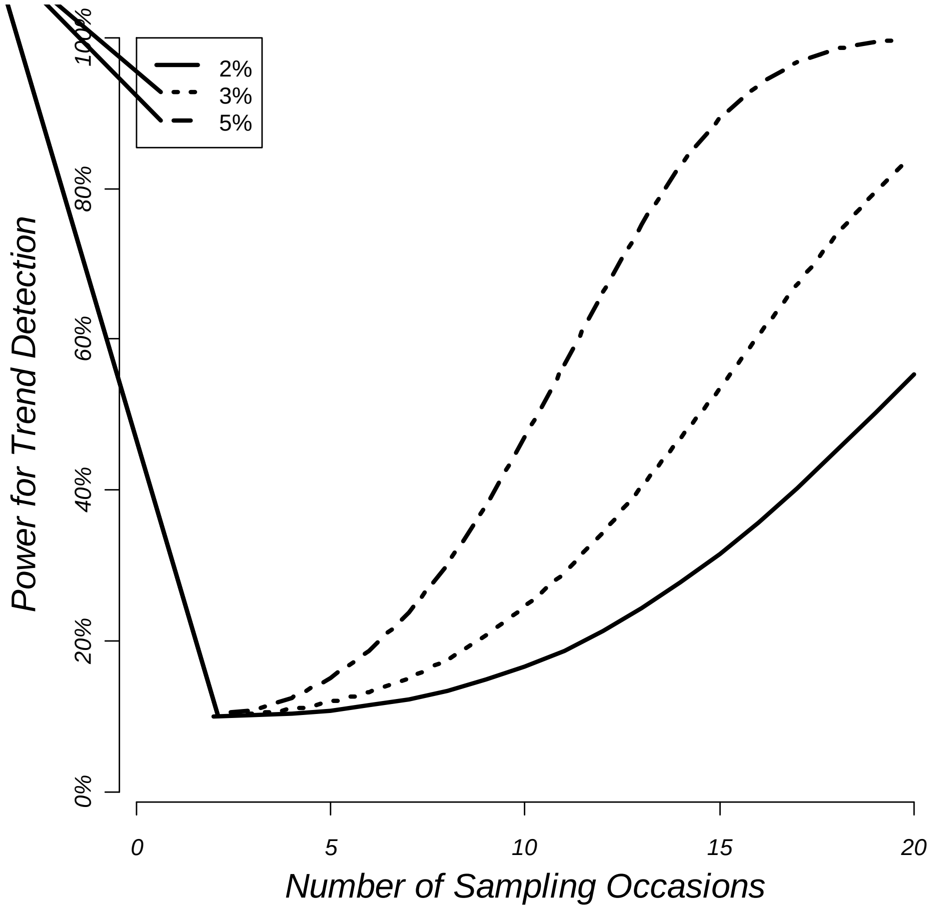

Figure 4. Estimated power for detecting annual trends in the median log-counts of 2%, 3% and 5% for 20 years with 12 caves sampled each year using the variance components of all caves.

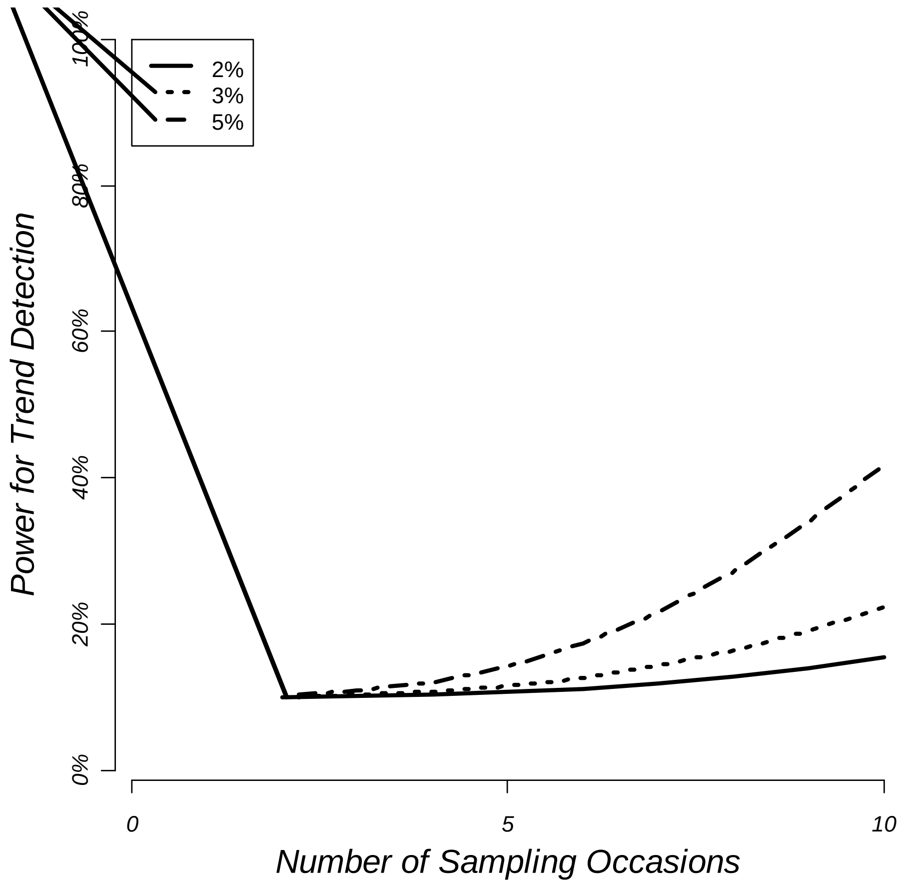

Figure 5. Estimated power for detecting annual trends in the median log-counts of 2%, 3% and 5% for 10 years with 10 caves sampled each year using the variance components of only 10 caves.

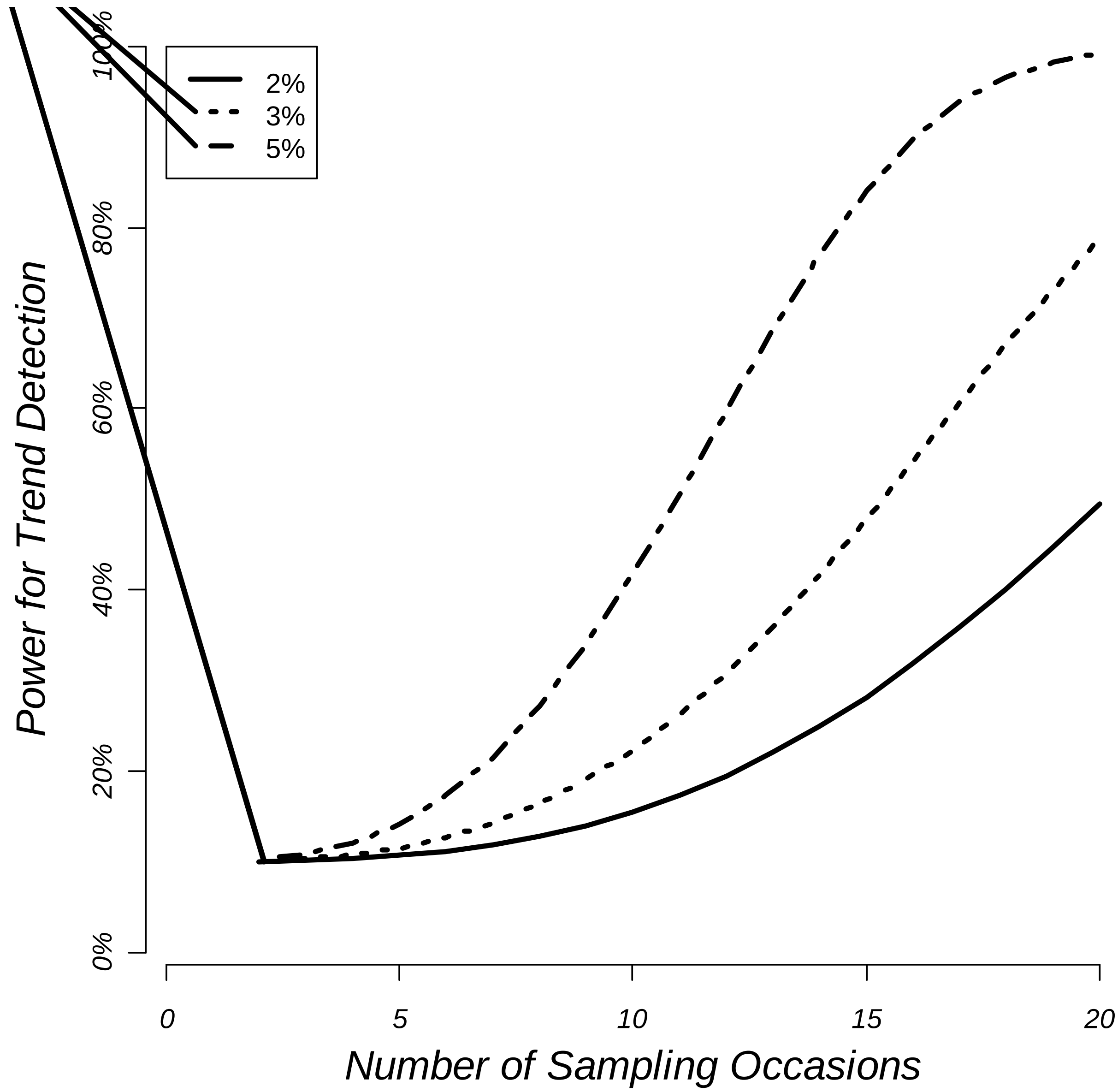

Figure 6. Estimated power for detecting annual trends in the median log-counts of 2%, 3% and 5% for 20 years with 10 caves sampled each year using the variance components of only 10 caves.

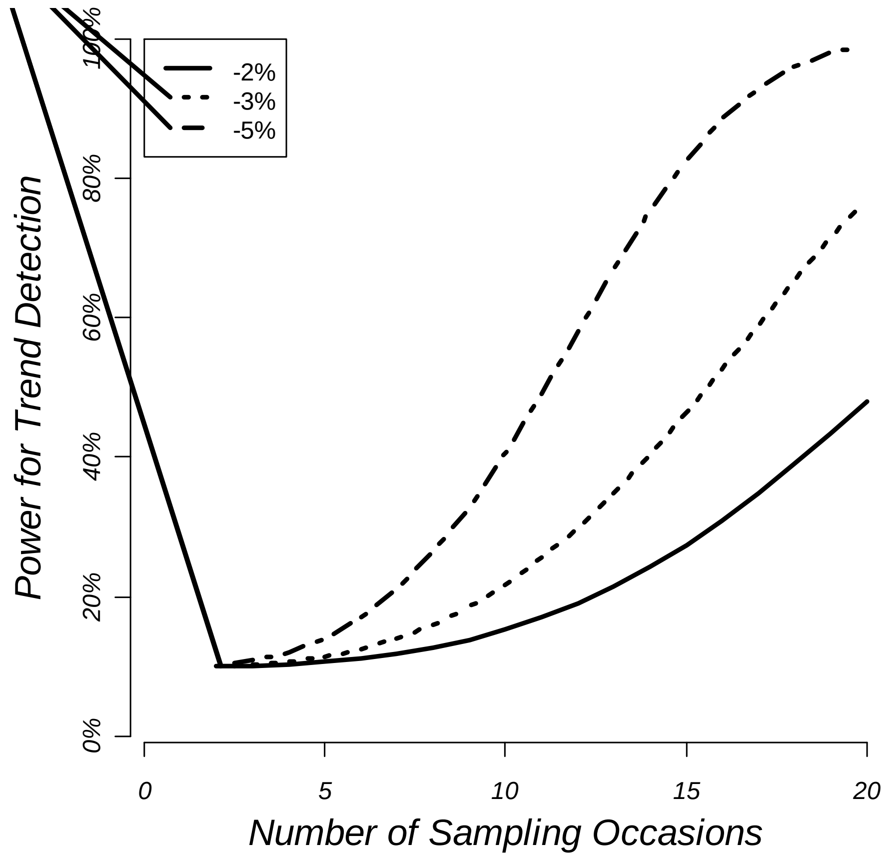

Figure 7. Estimated power for detecting annual trends in the median log-counts of -2%,- 3% and -5% for 20 years with 9 caves sampled each year using the variance components of only 10 caves.

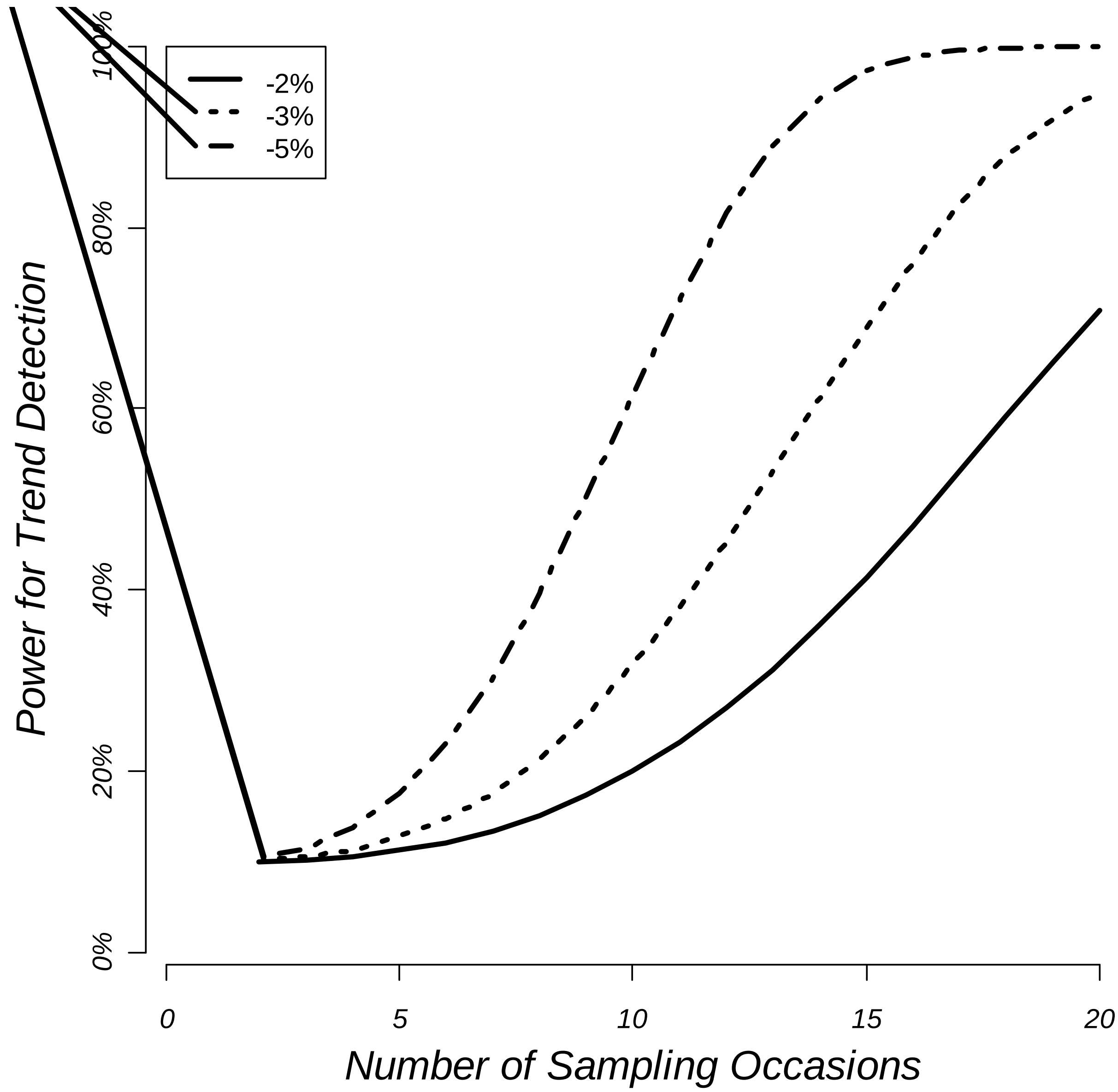

Figure 8. Estimated power for detecting annual trends in the median log-counts of -2%,- 3% and -5% for 20 years with 6 caves sampled each year using the variance components of only those 6 caves.

Conclusions

Figures 3 and 4 suggest that to detect an annual trend of 3% in the median bat counts (with Type 1 error of 10%) 80% power is achieved after 20 years. This annual trend corresponds to a net change in the median bat count of 60% (quite large). However, Figures 5, 6, and 7 suggest that reducing to only 10 or 9 caves does not significantly affect the power to detect annual trends, so much as the number of years of data collection. The power is quite sensitive to the magnitude of the year variance component; a way to increase power for detecting trends in bat counts would be to incorporate covariates that may account for this yearly variation in bat populations. The estimated power for the 6 caves that were selected to be monitored by the network is slightly higher than the power based on sampling 12 caves even though the sample size is smaller (Figure 8 and Figure 4). This is not surprising because the variance component estimates based on only those 6 caves are slightly smaller (Table 1).

References

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VanLeeuwen, D. M., Murray, L. W., and Urquhart, N. S. (2002). A mixed model for both fixed and random trend components across time. Journal of Agricultural, Biological, and Environmental Statistics, 1(4):435–453.